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WHAT MATHEMATICAL SUBJECTS SHOULD BE INCLUDED IN THE CURRICULUM OF THE SECONDARY SCHOOLS? FROM THE POINT OF VIEW OF THE COLLEGE.

By E. S. Crawley.

Mr. President, Ladies and Gentlemen: Had I followed the orthodox method in making preparation to speak on the topic here assigned me, I should no doubt have devised an elaborate questionnaire and sent it broadcast to my colleagues in this district. By so doing I should have made myself a source of annoyance to a large body of busy men, and have been able to come before you today with a mass of statistical matter showing the percentages of college teachers who favor this or that topic in the preparatory school curriculum. The questionnaire habit has however, become too prevalent. I dislike to receive these documents and have a lurking suspicion that others may have a like feeling, so I have refrained from adopting this method. Moreover, I do not believe that such procedure would have led us to any very satisfactory conclusion. The question immediately before us: "What mathematical subjects should be included in the secondary school curriculum—from the point of view of the College?" that is, with a view to mathematical work in college, is one which it seems to me can be answered categorically in only one way and that very briefly. When we say that what the colleges ask is that the fundamental principles and processes of mathematics be taught so far as they are set forth in the study of elementary algebra and geometry, all has been said that need be said. But you may reply, that is begging the question; what we wish to know is how best to do this. My rejoinder would be that I cannot tell you. The teacher in the secondary school can best decide that for himself. I say this for two reasons, first because what will serve in one case may not be at all suitable for another, and to attempt to prescribe details is for this reason futile. Moreover, and secondly, I consider that it makes very little difference what is taught, that is, how fully this or that topic is treated, provided always fundamental principles are insisted upon unceasingly and their use and application kept always in the students' view.

It seems to me, therefore, that the way in which I can best contribute my mite to this discussion is by calling attention to certain broad general considerations which in my experience with college students leads me to judge are not sufficiently kept in view in all cases.

Let us consider the matter of elementary algebra. Algebraic principles and processes are really few and simple. It is true that the text books divide the subject into a great many topics but if any of these be taken and analyzed it will readily be found that its treatment goes back to an application of principles already well established. Each topic can be subdivided into various cases and often is so subdivided. There is no objection to this if the underlying principle is always sought out and brought to light. But the teacher who makes a separate thing of each of these different cases in all the topics treated will not succeed, because he will swamp his students in multiplicity of detail. The student will form the habit of relying upon his memory of this or that point of detail for the particular case under discussion instead of simply applying the underlying principle. In this way if he has a good memory he will be able to show a certain superficial success, but he will not have learned anything about mathematics. More than this the possibility of his ever knowing anything about mathematics will be in a great measure destroyed by this process. I think that I have made clear what I mean, but let me illustrate briefly. Take the great question of the simplification of algebraic expressions, which after all embraces a very large part of the work in elementary algebra. Practically all of this is based upon one process, factoring, and one principle, that we may multiply or divide the numerator and denominator of a fraction by the same factor. Again the whole subject of the solution of quadratic equations is nothing more than an application of the fact learned very early in the study of algebra that the square of a binomial consists of three terms one of which is twice the product of the square roots of the other two. In geometry in the same way unless a student is brought to know the principles of geometric reasoning all his work goes for nought. He may it is true learn a few facts about geometry which will be of more or less importance to him practically, but he will not learn anything about mathematics.

Twice in this discussion the phrase that under specified conditions, a student will not learn anything about mathematics, has been used. In order that we should understand each other clearly it will be well to come to some agreement as to what we are to mean by "knowing something about mathematics." The phrase itself does not necessarily convey the same meaning to all minds. Before stating what in my opinion this phrase should mean for us, let me digress for a moment. This digression as you will see will lead us back to the point at issue. Let us glance for a moment at the subjects which find a place in the curricula of our secondary schools, which apart from mathematics form the bulk of these curricula. We find the greater part of the time devoted to languages, literature and history. Each of these subjects has a certain informational value, but it is not primarily for this that they hold the place assigned them. Is it not because in all of these we find a great human interest, because each in its own way is a record of the way men, the great men of the world, have thought or spoken or acted? I think that therein lies their value. We want to have our boys and girls study about these things because they will learn in this way how men who have gone before and how those now in the world think and act. So it should be in the study of mathematics. This study is important because it reveals how men have thought about the problems which belong to the sphere of mathematics and how they have conquered them. When I speak of "knowing something about mathematics," I mean therefore something of this kind—you can get my meaning from what has been said better perhaps than I can express it—I mean getting some insight into the beauty and simplicity of mathematical processes and mathematical principles, something of the wide extent of the mathematical domain; for we live in a mathematical world far more truly than we ordinarily realize. We have but to consider not only how mathematical laws control the operations of nature, but also how they are at the basis of most of our material activities to see how this is so. And the keynote of it all is simplicity. The same little "two and two make four" principles run through it all. I call them little not because they are insignificant, but because they are so plain and easily understood. In their application their results are often of tremendous importance.

We hear in these days a great deal about the difficulties of mathematics. Books and papers are written, addresses are made, and associations meet for discussion, all upon this great subject of how difficult mathematics has become for our boys and girls, and about what we should do to make it easier. I believe that all this is wrong because in the first place, so far as any real difficulties are concerned, there are none, and in the second place those things which appear to be difficulties do so mainly from causes which have no essential connection with mathematics. They appear as difficulties owing to lack of concentration, lack of persistence, lack of patience, which is almost the same thing, and probably to lack of imagination. I might add to this, if I were not afraid you would think me too old-fashioned, a lack of reverence for those things and those ways of thinking, simply for their own sake, which have enabled men to reach the place which the world occupies today. The joy of intellectual effort and the satisfaction of achievement in the same field are too little known and valued amongst our school boys and girls today.

Now let us see in a more concrete way in what these so-called difficulties consist. The student faces a complicated algebraic expression, or a problem in geometry the solution of which is not too painfully evident. Does it arouse him to effort, does he see in it something to conquer, something against which to pit his intellectual brawn? Too often not. He has not been trained to do that sort of thing. His brain is flabby from disuse and his ambition atrophied. What is needed first is that he should have enough grit, or "sand" as we call it now, to refuse to be conquered by such a trivial thing, and then that he should go to work patiently and persistently, taking the thing step by step, applying a few simple principles carefully and accurately, and the thing is done. But patience, persistence and accuracy do not appear to be included in the list of school boy or girl virtues. Fortunately there are some who come through the schools with ability to do this sort of thing. They are perhaps natural leaders in their respective fields of endeavor, but at all events they know what they want to do, and have the energy to make the effort to do it. I fear you may think that I am by implication giving the schools some hard knocks. That certainly is not my object, but I should be falling short of my duty if did not present the matter as I see it. So far as the schools and colleges are concerned I believe that they are manned by a force of men and women who rank considerably above the average in conscientiousness and in devotion to duty, and that they give to their students the best that is in them. Why then should we harp so continually upon this one string of unsatisfactory results? It cannot all be imaginary, nor do I think that the explanation is to be found in any very great advance in our standard of efficiency over that which satisfied former generations working in the same lines, although we have perhaps advanced somewhat in this way. Still the main source of the trouble must be sought elsewhere, and I want to make a suggestion touching this and leave it for your consideration to determine how nearly I may be right.

We are all aware that educational expansion in this country has advanced during the last two or three decades with tremendous leaps. The percentage of the population enrolled in the high schools, colleges, and universities, is continually advancing. Is it therefore not reasonable to conclude that the average of the natural intellectual endowment of students who are now seeking higher education is lower than formerly, and that consequently we must seek the root of our troubles not in our methods but in the material which we have to handle. I believe that this view of the matter is worth thinking about. If there is any truth in it, what are we going to do about it? It is a trite saying that many a good shoemaker is spoiled to make a poor lawyer, and we all know the old proverb about trying to make a silk purse out of certain unpromising material. Are we trying to make too many silk purses under circumstances which forbid hope of success? If so, I repeat, what are we going to do about it? It is easier to ask the question than to answer it, and I am obliged to confess that I have nothing to suggest, and must leave it in your hands. Whatever our conclusion upon this important and far-reaching question, we must face present conditions as we find them, and to return to the specific question of this discussion, let me conclude by urging again the importance in mathematical work in the schools of the simple inculcation of principles. Teach the students always to base their work on the underlying principles. Banish memory work from mathematics, except for the everyday formulæ, for definitions and for such of the results as require to be fixed in the mind for future reference. Stimulate brain effort. If you can so conduct your work, you will need no prescription as to what to teach in preparation for college beyond the simple one already given,—elementary algebra and geometry.

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